Proton femtoscopy in STAR at RHIC

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Nantes

Outline

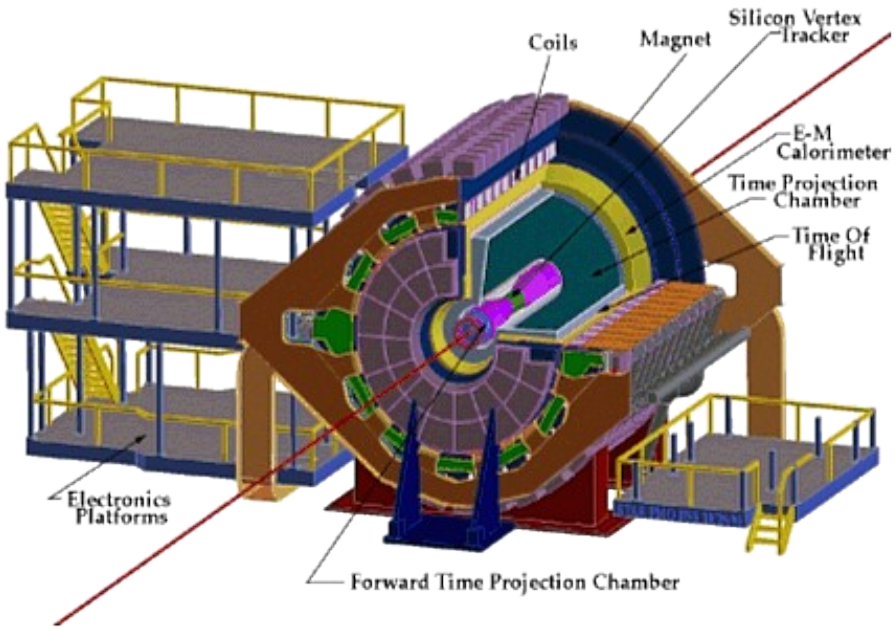
- Few words of introduction
- Interactions present in baryon correlations
- Identical and non-identical (anti)proton combinations
- The contribution of Residual Correlations + their estimation
- The fraction of pure p -p correlation
- Correlation functions
- m_T dependence (validity of flow description checked)

STAR experiment

Solenoidal **T**racker **A**t **R**HIC

Located at **R**elativistic **H**eavy **I**on **C**ollider (RHIC) in

Brookhaven **N**ational **L**aboratory (BNL)



Designed to measure the properties of hot and dense matter created in heavy ion collisions at ultrarelativistic energies.

Few words about femtoscopy

Single- and two- particle distributions

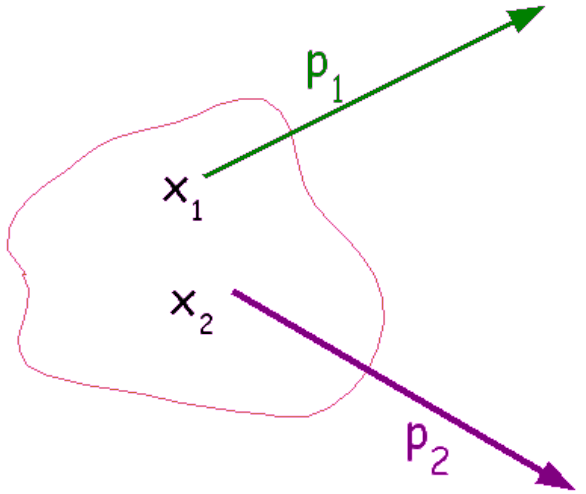
$$P_1(p) = E\frac{dN}{d^{3p}} = \int d^{4x} S(x,p)$$

S(x,p) – emission function: the distribution of source density probability of finding particle with x and p

$$P_2(p_1,p_2) = E_1 E_2 \frac{dN}{d_1^{3p} d_2^{3p}} = \int d^4x_1 S(x_1,p_1) d^4x_2 S(x_2,p_2) \Phi(x_2,p_2|x_1,p_1)$$

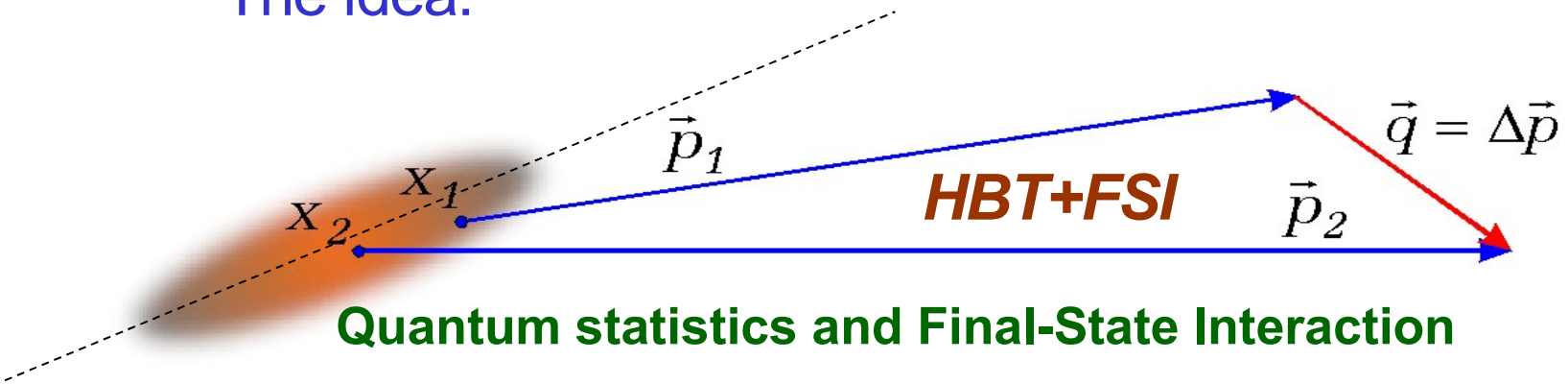
The correlation function

$$C(p_1,p_2) = \frac{P_2(p_1,p_2)}{P_1(p_1)P_1(p_2)}$$



Few words about correlation technique..

The idea:



Quantum statistics and Final-State Interaction

Space-time sizes and dynamics (cannot be measured directly)

close velocity correlations

Momenta and momentum difference (can be measured)

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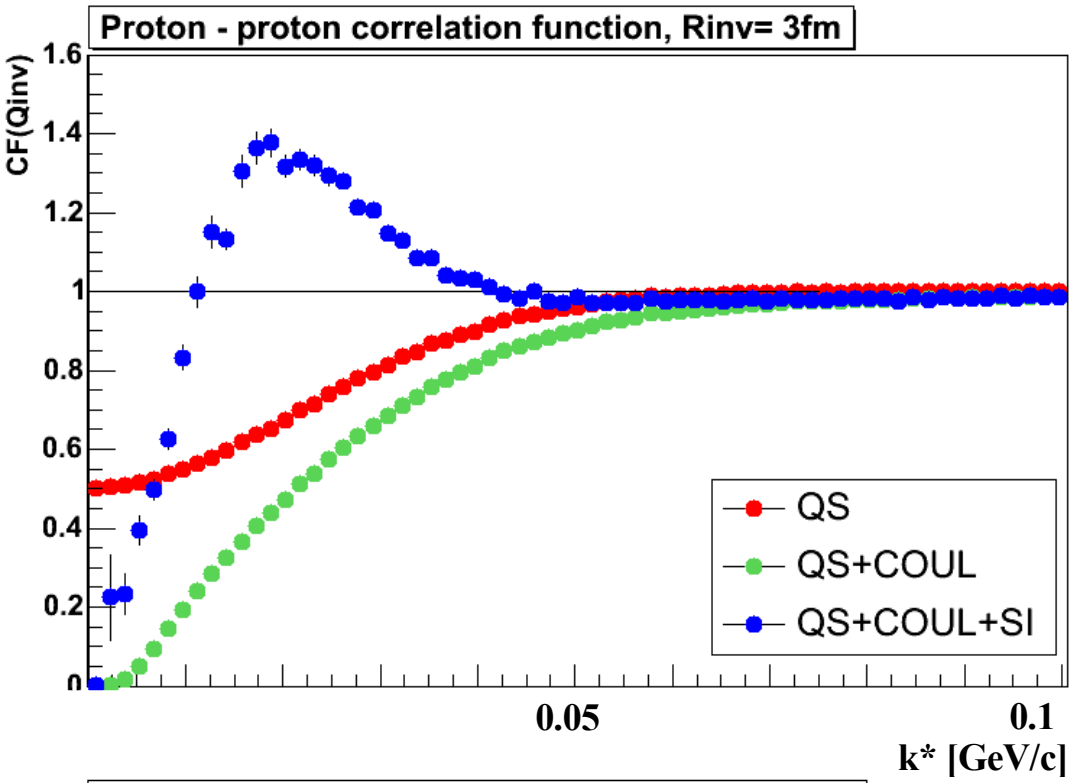

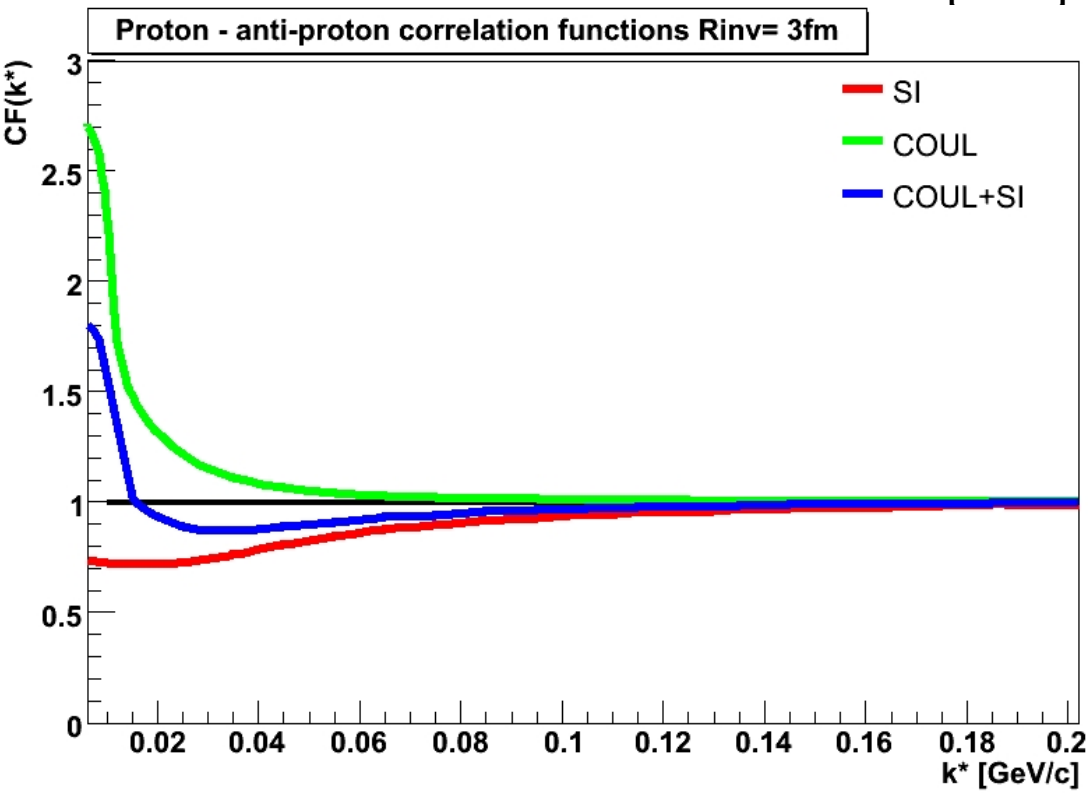

Proton- (anti)proton correlations

Identical baryon- baryon

- Quantum Statistics- **QS**

- Final State Interactions- **FSI**
  - **Coulomb**
  - **Strong**

Nonidentical baryon- (anti)baryon

- Final State Interactions- **FSI**
  - **Coulomb**
  - **Strong**

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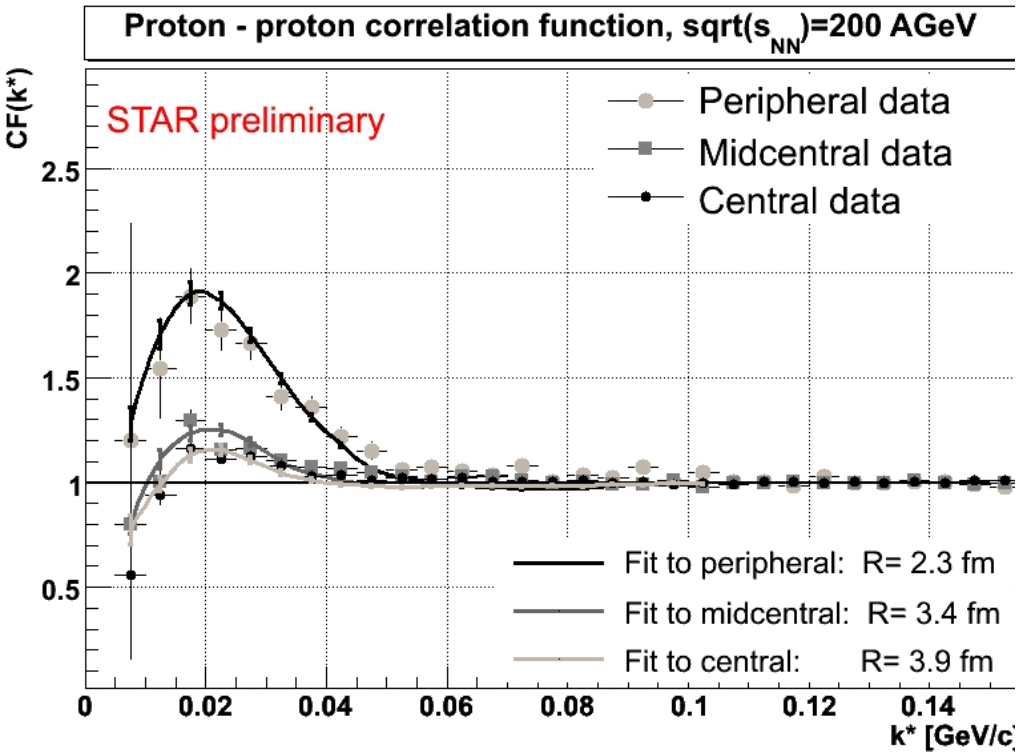
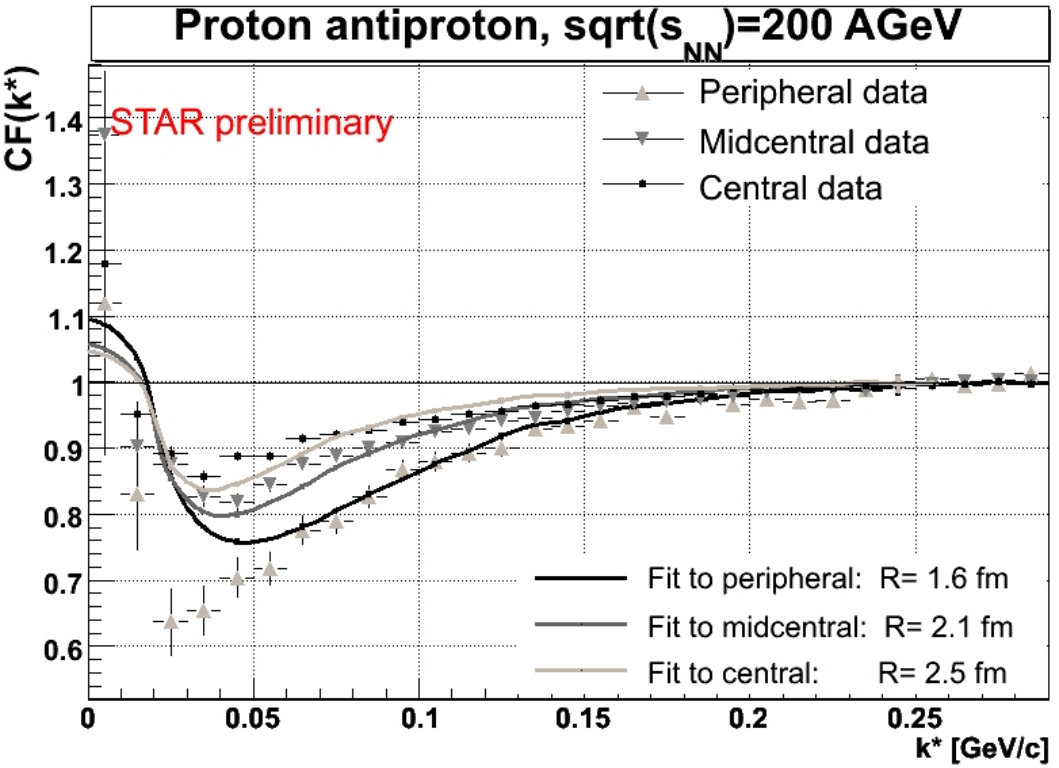
Baryon-baryon: with simple corrections





	$p-p$	$\bar{p}-\bar{p}$	$p-\bar{p}$
peripheral	$2.3^{+0.1}_{-0.1}$ *fm*	$2.4^{+0.1}_{-0.2}$ *fm*	$1.6^{+0.1}_{-0.1}$ *fm*
midcentral	$3.4^{+0.1}_{-0.1}$ *fm*	$3.5^{+0.1}_{-0.1}$ *fm*	$2.1^{+0.1}_{-0.1}$ *fm*
central	$3.9^{+0.2}_{-0.1}$ *fm*	$4.5^{+0.1}_{-0.1}$ *fm*	$2.5^{+0.1}_{-0.2}$ *fm*

2 different sizes!
2 different sources?

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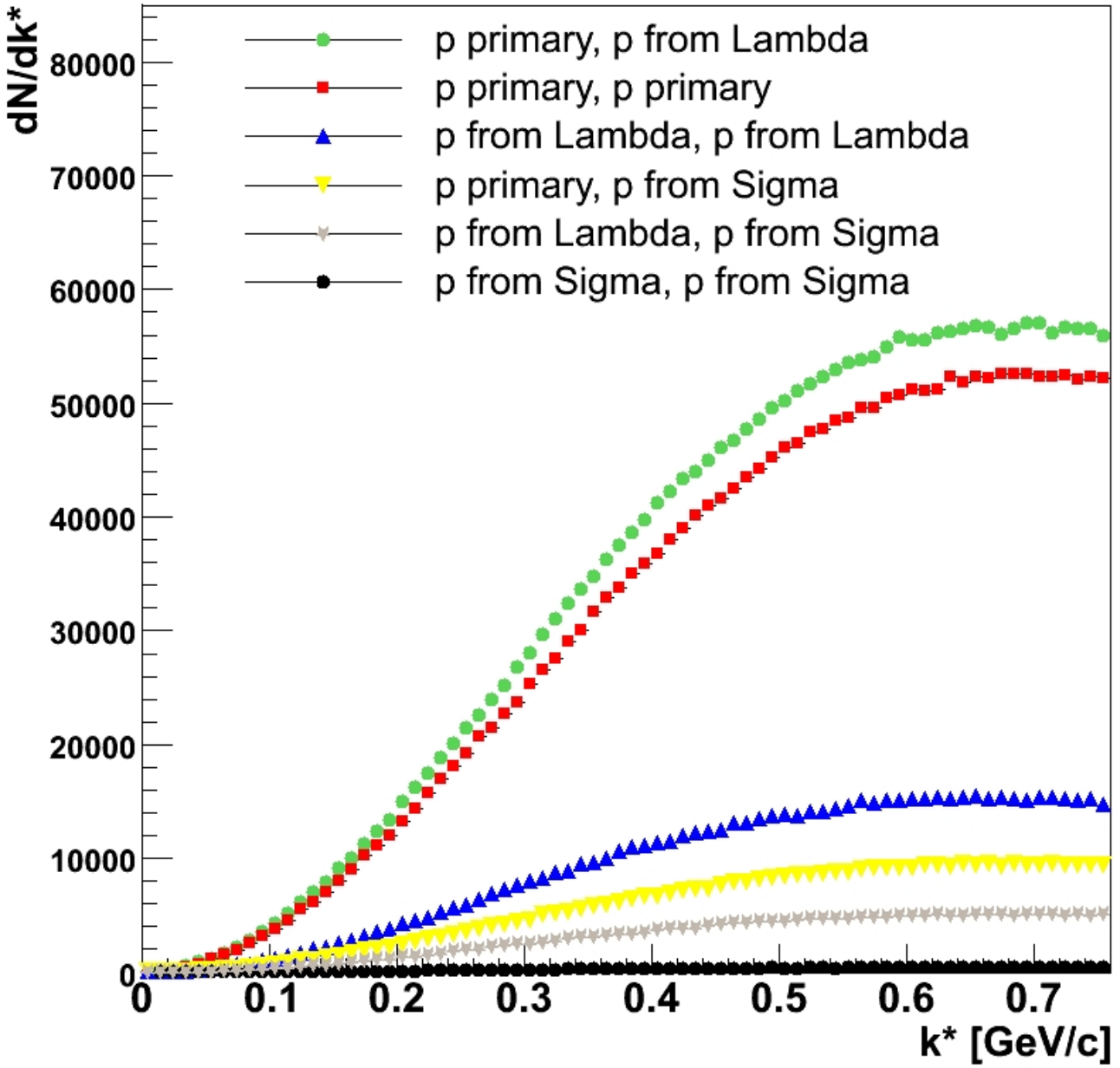
Contribution to the measured correlation function

$$CF_{true}(k_{star}) = \sum_{x,y=\,p,\Lambda,\Sigma} CF_{x-y}(k_{star})\, F_{x-y}(k_{star})$$



$$F_{x-y}(k_{star}) = \frac{f_{x-y}(k_{star})}{\sum_{i,j=\,p,\Lambda,\Sigma} f_{i,j}(k_{star})}$$

$$x, y = [\,p, \Lambda, \Sigma\,]$$

weak decay channels of interest:

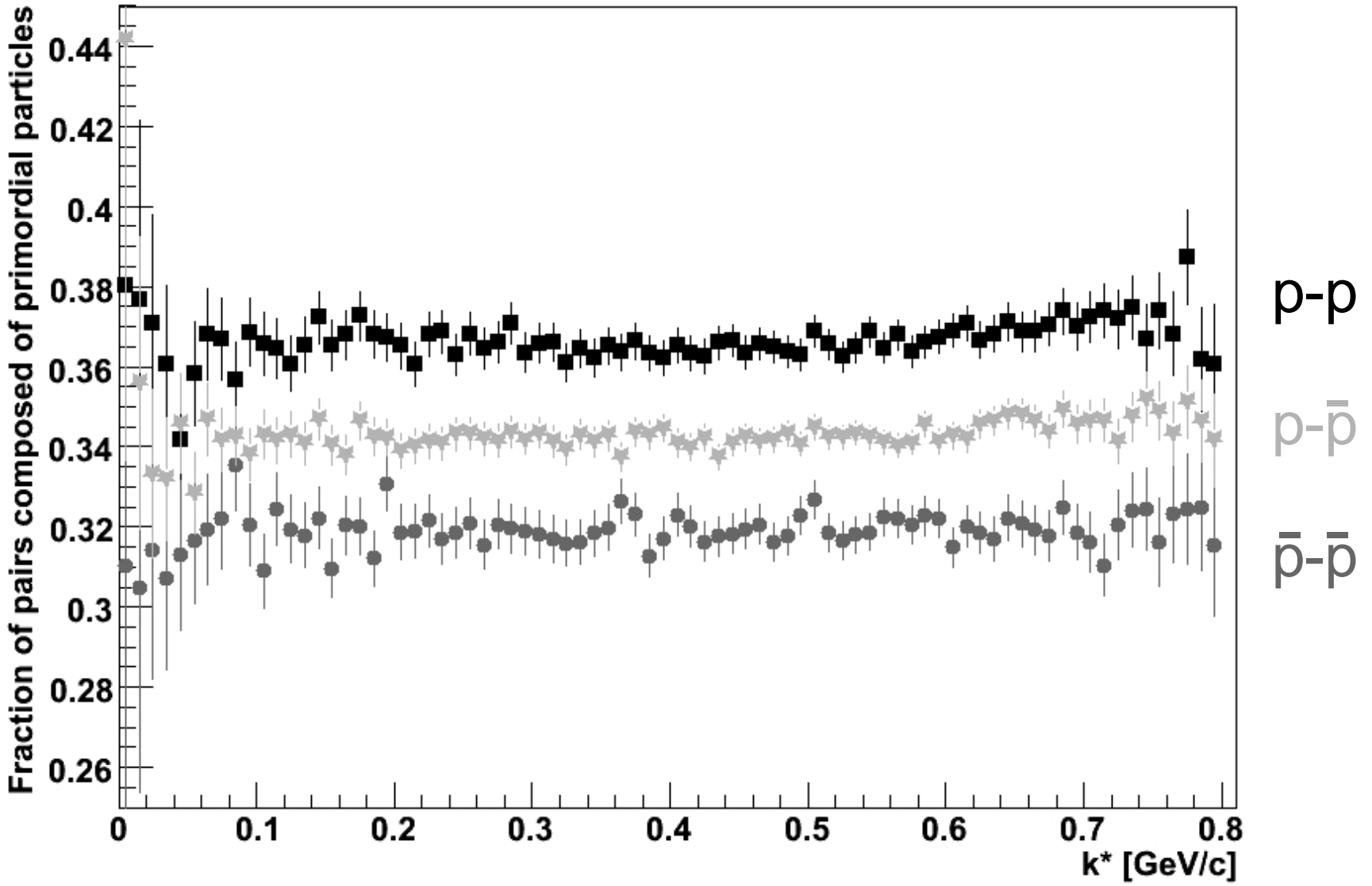
$\Lambda \rightarrow p + \pi^-$, $\Lambda_{bar} \rightarrow p_{bar} + \pi^+$

$\Sigma^+ \rightarrow p + \pi^0$, $\Sigma^+_{bar} \rightarrow p_{bar} + \pi^0$

THERMal heavy IoN generATOR (Broniowski, Florkowski, Kisiel, Tałuć: nucl-th/0504047)

The fraction of proton-proton pairs

$$F_{p-p}(k_{star}) = \frac{f_{p-p}(k_{star})}{\sum_{i,j=\,p,\Lambda,\Sigma} f_{i,j}(k_{star})}$$



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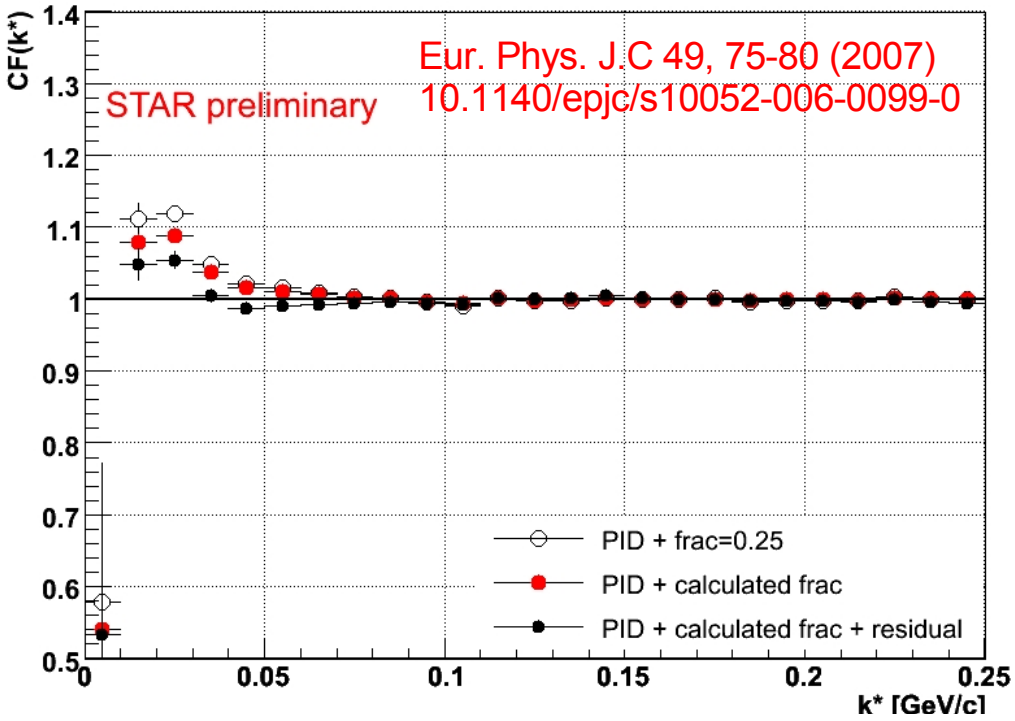
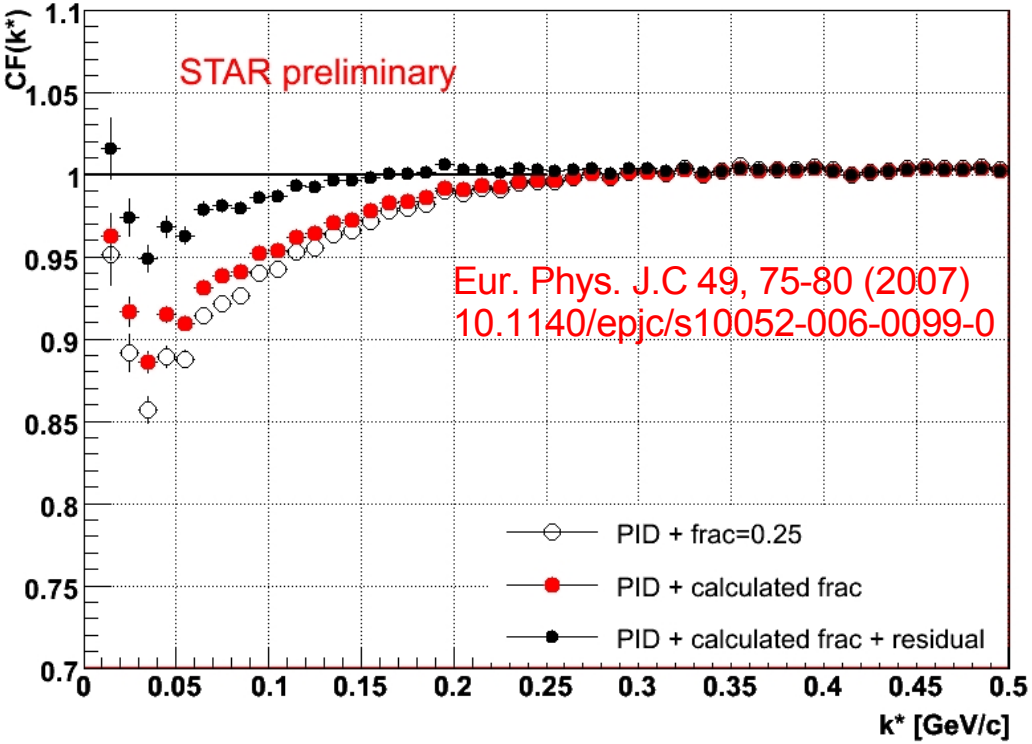
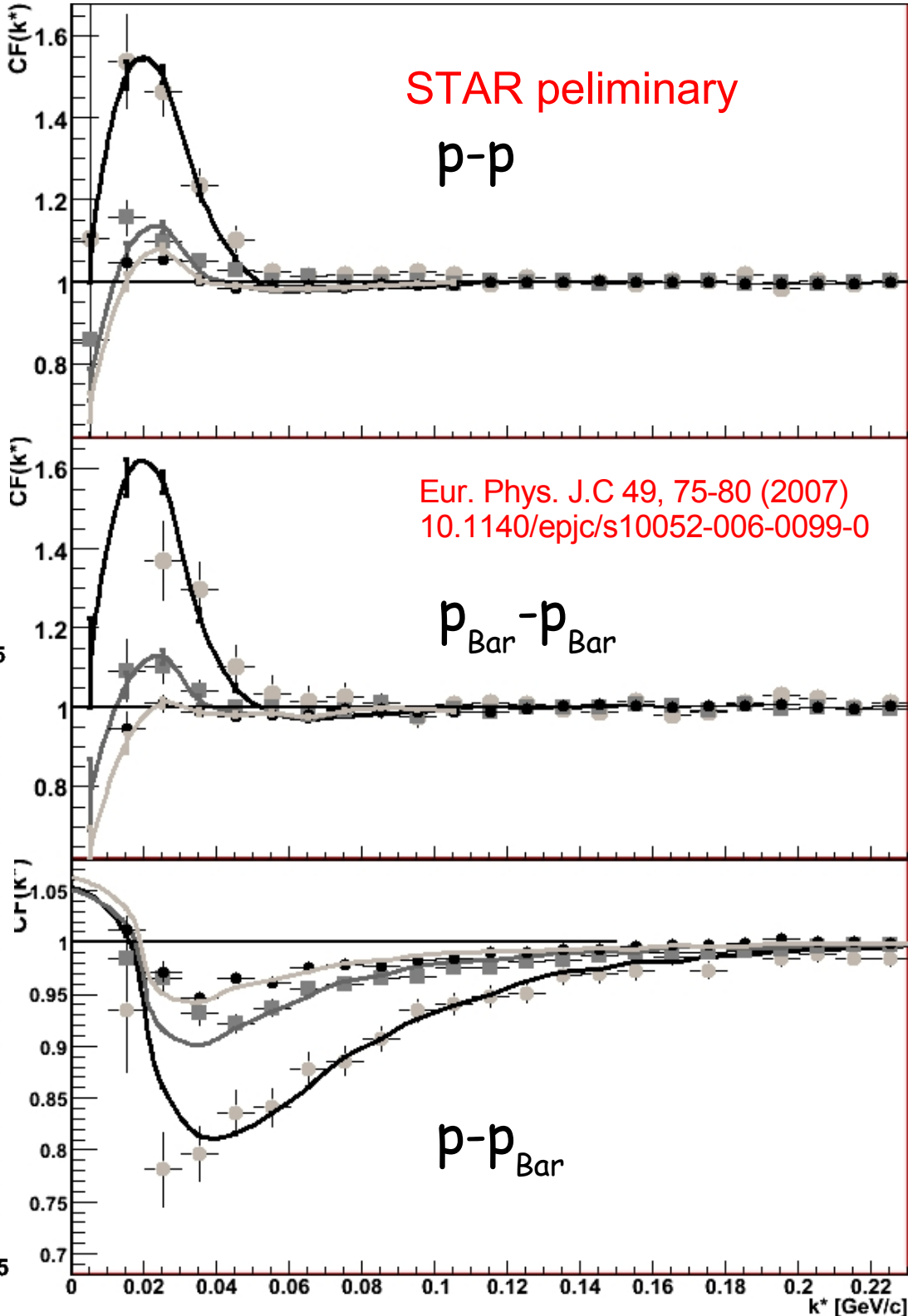
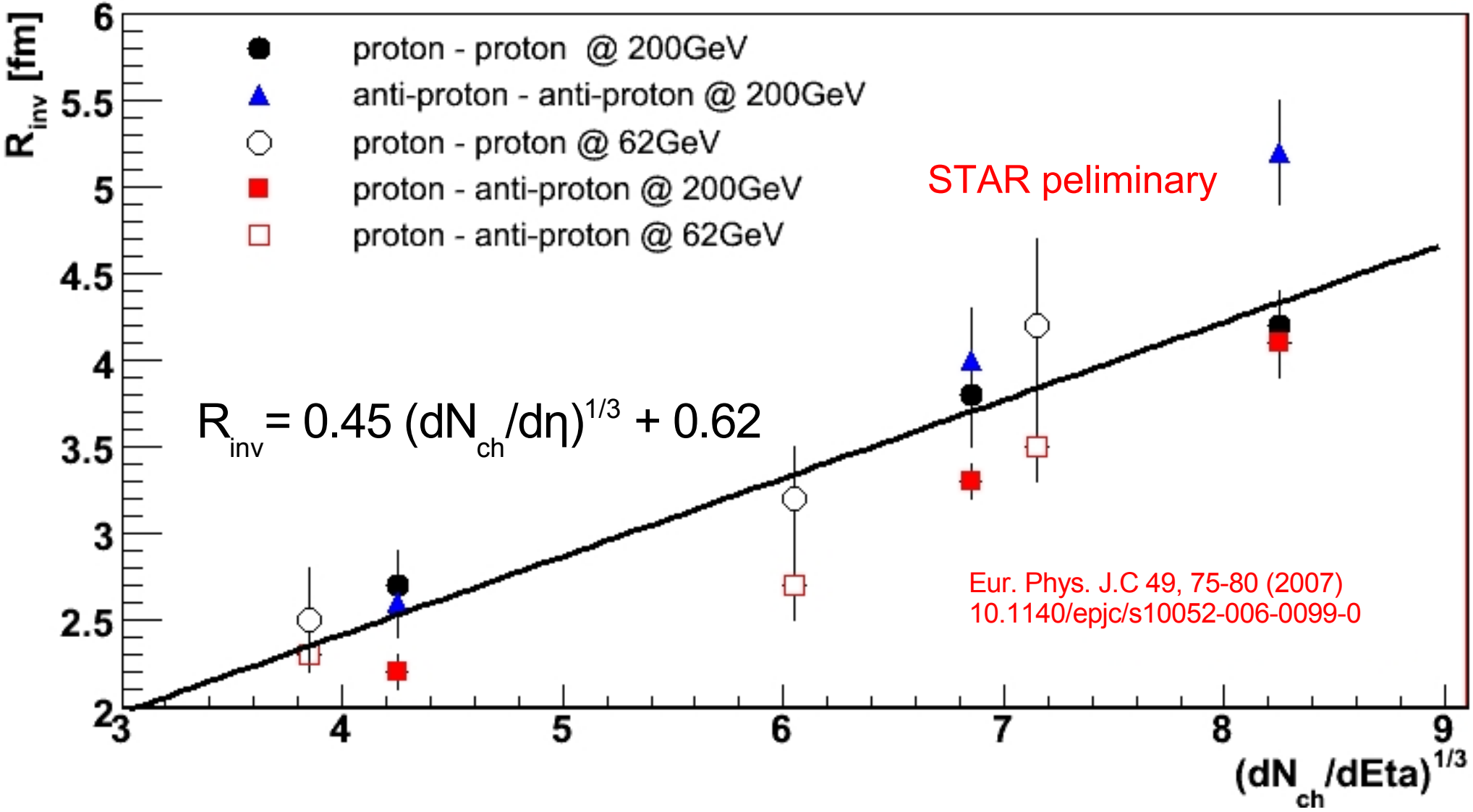
Final results







Proton-proton, antiproton-antiproton, proton- antiproton



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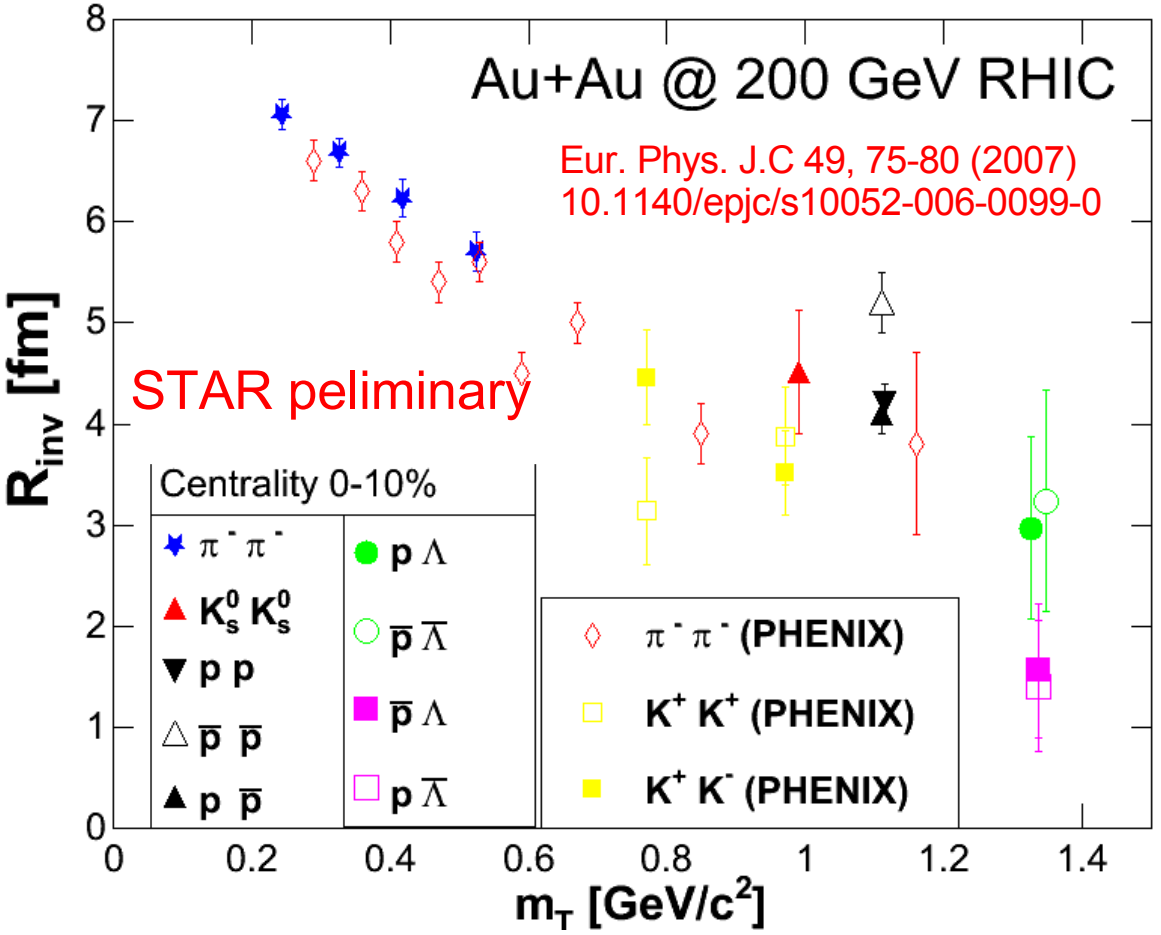
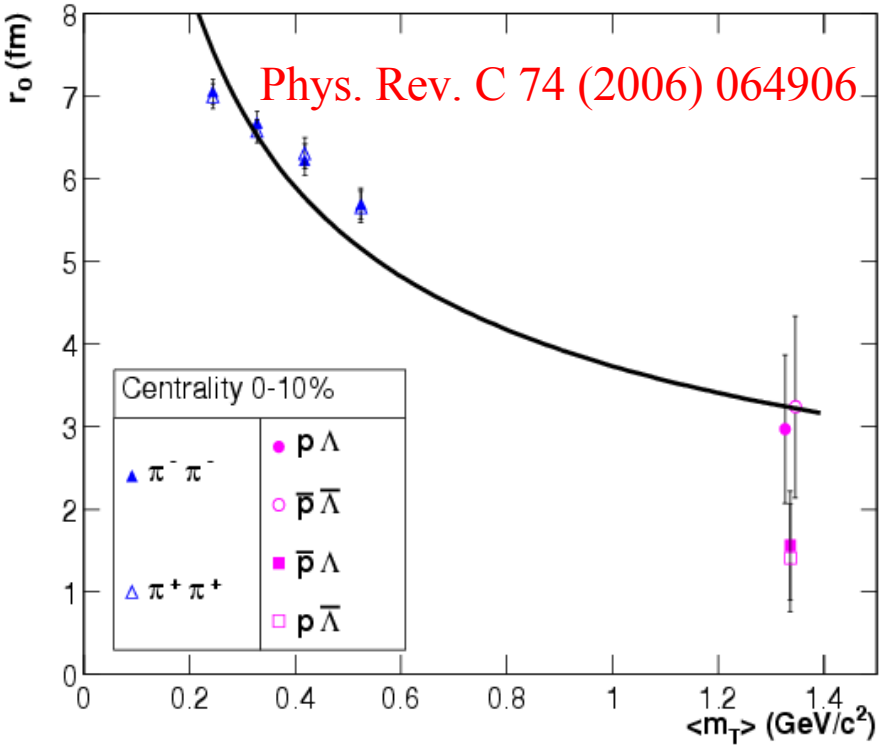
m_T dependence





Not taking into account the residual correlations- may lead to the misunderstanding of results!

System	r_0 *(fm)*
$\bar{p} - \Lambda + p - \bar{\Lambda}$	$1.50 + 0.05^{+0.10}_{-0.12}$
$p - \Lambda + \bar{p} - \bar{\Lambda}$	$3.09 + 0.30^{+0.17}_{-0.25}$

Conclusions

- Proton-proton, antiproton-antiproton, proton-antiproton correlations for Au+Au @ 200GeV and 62 GeV are shown

- Proton femtoscopy is a new insight into baryon production and interaction processes thanks to the large STAR data collections

- It allows the extraction of proton and antiproton source size parameters with a very good accurancy

- Residual correlations play a crucial role in baryon systems

- Residual correlations affect non-id systems more

- We record a very good agreement between the experimental results and the theoretical predictions

- After removing RC- there are still small differences (source sizes are the same in error bars)

- Proton source sizes scales as predicted by flow

Thank you for your attention!